Vertical Integration in the Presence of Upstream Competition

by

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We analyse vertical integration when there is upstream competition and compare outcomes to the case where upstream assets are owned by a single agent (i.e., upstream monopoly). In so doing, we make two contributions to the modelling of strategic vertical integration. First, we base industry structure – namely, the ownership of assets – firmly within the property rights approach to firm boundaries. Second, we model the potential multilateral negotiations using a fully specified non-cooperative bargaining model designed to easily compare outcomes achieved under upstream competition and monopoly. Given this, we demonstrate that vertical integration can alter the joint payoffs of integrating parties in ex post bargaining; however, this *bargaining effect* is stronger for firms integrating under upstream competition than upstream monopoly. We also consider the potential for integration to internalise competitive externalities in manner that cannot be achieved under non-integration. We demonstrate that ex post monopolization is more likely to occur when there is an upstream monopoly than when there is upstream competition. Our general conclusion is that the simple intuition that the presence of upstream competition can mitigate and reduce the incentives for socially undesirable vertical integration is misplaced and, depending upon the strength of downstream competition (i.e., product differentiation), the opposite could easily be the case. *Journal of Economic Literature* Classification Number: L42

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1 Introduction

There are long-standing antitrust concerns about potential social detriment from vertical integration, centering on integration by an upstream monopoly into the downstream segment. The monopolist may restrict supply after integration and foreclose on downstream rivals, or it may appropriate more of the rents at the expense of downstream firms. Moreover, there is a general belief that improving competition in the bottleneck segment would alleviate these concerns.[1]

There are two ways that competition might serve to discourage socially harmful vertical integration. First, upstream competitors will respond to attempts by a firm to foreclose on rivals by expanding their supply to the downstream. Thus, a firm facing competition will not be able to use vertical integration to raise prices in the industry. Second, it is claimed that competition reduces any bargaining power conferred on the monopolist by integration and the threat of foreclosure.

To date, there has been no comprehensive theoretical analysis of the role that competition plays on the incentives for vertical integration and its social desirability. This paper provides such an analysis. In so doing, our primary task is to provide a model capable of studying the pure effect of an increase in competition. Thus we need to consider an environment where competition does not otherwise change total resources, technical productivity in the industry or the nature of bargaining in an ad hoc manner. To this end, we consider an environment where there are two downstream and two upstream assets. Upstream competition is modeled as a situation where the two upstream assets are separately owned, whereas under upstream monopoly they are commonly owned.

Our main modeling contribution, however, lies in the game we use to model bargaining between upstream and downstream firms over input supply. We consider an environment, common in the property rights approach to firm boundaries (Grossman and Hart, 1986; Hart and Moore, 1990), where the manager of each asset has asset-specific skills, and integration decisions – i.e., the ownership of assets – are made prior to

[1] See Williamson (1987) for a discussion of these presumptions.

bargaining over the supply of inputs. This set-up allows us to consider the bargaining effects of vertical integration in a similar manner to the standard property rights literature. In particular, in our environment, integration does not remove the potential for the manager of an acquired firm to accrue rents. This is true both for a firm integrating vertically but also for an upstream monopoly where one upstream asset is owned by the manager of the other. Thus, we can capture the full effects of integration on bargaining relations in the industry. Moreover, in so doing, we are able to investigate new issues in strategic vertical integration; namely, the potential differences between forward and backwards integration.

Bargaining takes a non-cooperative form with each upstream-downstream pair negotiating sequentially over the quantity supplied and the non-linear price between them. Irrevocable breakdowns in negotiations between any upstream and downstream firm constitute a "material change in circumstances" as specified in many contracts, and thereby trigger renegotiations of any previously agreed upon supply contracts. Thus supply arrangements are non-binding in the sense considered by Stole and Zwiebel (1996) for employment contracts. Here, we interpret the non-binding nature of agreements as indicative of a difficulty in writing long-term contracts relative to decisions regarding firm structure. We demonstrate that the distribution of the surplus from this type of bargaining is similar to that arising from the Shapley value concept in cooperative game theory. At the same time, this type of bargaining leads naturally to some of the inefficiencies emphasized in the contracting externalities literature: an upstream supplier with more than one buyer downstream oversupplies the market, because they cannot commit not to impose negative externalities on one buyer by selling large quantities to the other buyer.[2]

We demonstrate that vertical integration has two potential effects. First, the bargaining position of all agents changes. Second, some contracting externalities are internalized. To demonstrate the first, we initially consider an environment where downstream assets are in different markets so that there are no competitive externalities

[2] The seminal work on this comes from Hart and Tirole (1990) in terms of its relationship to vertical integration. However, McAfee and Schwartz (1994), O'Brien and Shaffer (1992) and Segal (1999) provide comprehensive treatments of the contracting problem when there are externalities amongst firms. See Rey and Tirole (1997) for a survey.

between them (Section 3). There vertical integration changes only the distribution of bargaining power and not the surplus generated. We show that vertical integration can increase the sum of payoffs for the integrating parties because it improves their bargaining position in negotiations with independent firms; specifically, it eliminates the possibility of market structures that may be favourable to independents.

Importantly, we demonstrate that there is a *greater* incentive for vertical integration under upstream competition than under monopoly. This is because the bargaining benefits come from the redistribution of rents from non-integrating parties; and in a monopoly, the non-integrating parties already have low rents. Thus, competition enhances rather than reduces the potential for purely strategic vertical integration. Moreover, we find that integration occurs from the *more* competitive segment into the *less* competitive segment: for example, forward integration is chosen over backward integration only when upstream firms are closer substitutes than downstream firms.

When competitive externalities downstream are taken into account, there is an additional incentive for vertical integration: integration can internalize those externalities and lead to some degree of monopolization in the industry. The integrated upstream firm, when dealing with the non-integrated downstream firm, will internalize the effect of its supply on its own downstream firm. Vertical integration of an upstream monopolist leads to higher industry profits than are possible under upstream competition, raising the returns to integration under upstream monopoly relative to upstream competition and mitigating the returns identified earlier that were based purely on bargaining. Indeed, we demonstrate that in some situations, industry profits may fall (along with consumer surplus) as a result of vertical integration under upstream competition.

In this environment, we identify product differentiation as a key parameter driving incentives to vertically integrate. In particular, we find that when product differentiation is low (high), backward integration is more (less) privately profitable than forward integration. Importantly, while the conventional concern about vertical integration is confirmed when downstream products are relatively homogeneous, the incentive for such integration will be higher from upstream competition than upstream monopoly if products are relatively differentiated. Both these results suggest that the conventional approach of examining the market power of the acquiring firm will not necessarily allow one to draw a conclusion as to whether vertical integration is anti-competitive or not.

The paper that is closest to our own is that of Hart and Tirole (1990) – hereafter, HT. That paper is the first to identify the bargaining and monopolization effects that arise from vertical integration.[3] While their paper identifies these using three separate variants – each with extreme assumptions regarding downstream demand and upstream costs – our model nests all of those variants within a single model that allows for more general downstream and upstream environments; in particular, we allow for downstream product differentiation that is identified as an important driver of incentives for integration.[4] Thus, one contribution of our paper is to demonstrate the robustness of HT's results.[5] Nonetheless, we identify subtle differences between our conclusions and theirs throughout. For instance, as in HT, we demonstrate that in some cases vertical integration may lead to a situation where there is foreclosure in input supply to the non-integrated downstream firm. However, in our model, this does not necessarily imply there is foreclosure in payments to that firm, as the integrated firm is interested in preserving supply to that firm as an option if bargaining with its internal manager were to break down.

Significantly, however, HT's model is not equipped to properly examine the questions that motivate us here. First, they assume that upstream and downstream firms simply share the surplus arising from a negotiation according to a fixed parameter, rather than model the drivers of bargaining power—in particular, the asset-specific skills that confer bargaining power in the property rights literature.[6] Consequently, there is no

[3] Bolton and Whinston (1993) also identify a bargaining effect from vertical integration. Their model, however, does not have downstream firms directly competing, focusing instead of the impact of bargaining on investment incentives. Their analysis is complementary with that here although, like HT, it is formulated in a special manner to remove any distinction between forward and backward integration.

[4] A recent paper by Chemla (2002) also nests a bargaining and monopolization effect. He demonstrates that an upstream monopolist may expend resources to encourage entry by downstream firms so as to limit their bargaining power. He demonstrates that vertical integration will have the dual effect of reducing the monopolist's need to expend those resources and also lead to higher industry profits. de Fontenay and Gans (1999) similarly demonstrate that vertical integration can lead to reduced downstream entry and higher industry profits, but do so using a bargaining framework similar to that considered in this paper, although without an incomplete-contracts perspective on the effect of integration. The current paper does not study the effect of changes in bargaining power the entry decisions of firms, but focuses its attention on the effect of upstream competition.

[5] Many of HT's results rely on integration precipitating exit of an upstream or downstream firm. We demonstrate similar bargaining and monopolization effects to HT but without the use of the exit device that drove many of their results.

[6] Other papers in the literature avoid the need to model the drivers of bargaining power by assuming that

distinction between forward and backward integration. In contrast, in our model, the bargaining position of each firm is driven by their roles in possible market structures that arise following breakdowns in individual negotiations. As forward and backwards integration have different implications as to what market structures are feasible, there will be a difference in the incentives and impact of each.

Second, their analysis of the impact of upstream competition is limited to an analysis of the efficiency of the weaker upstream firm. That is, they consider what happens to the incentives to vertically integrate as the weaker upstream firm becomes more efficient, which confounds the effect of market power and the effect of superior productivity. Our analysis of the impact of upstream competition models competition as the horizontal integration of both upstream assets. And as such, it explicitly considers the impact of vertical integration on internal arrangements within the upstream monopoly.

In terms of its bargaining game, the paper has several antecedents. Grossman and Hart (1986) and Hart and Moore (1990) were the first to focus on Shapley values as likely outcomes of the bargaining game between firms. Variants of the bargaining game developed by Stole and Zwiebel (1996) have been applied to bargaining between firms over variable quantities by de Fontenay and Gans (1999), Inderst and Wey (2002) and Björnerstedt and Stennek (2001).[7] Note that contracting externalities are ruled out in all of the above game structures: the first rules it out axiomatically, while the latter two consider environments in which downstream players impose no externalities on each other. Here instead we allow sequential contracting in an environment in which downstream players are in the same market, leading to contract externalities as explored elsewhere in the literature on vertical integration.

The remainder of the paper proceeds as follows: Section 2 sets up our basic model and, in particular, the non-cooperative bargaining game that is capable of assessing the impact of upstream competition on the incentives for vertical integration. Sections 3 and 4 then provide analyses of the no externalities and competitive externalities cases when one vertical merger is possible. Section 5 then considers incentives for a second merger

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either upstream or downstream firms have all of the bargaining power (Rey and Tirole, 1997; Chemla, 2002). This is also a common assumption in the contracting with externalities literature (McAfee and Schwartz, 1994; and Segal, 1999).

[7] Only de Fontenay and Gans examine vertical integration; Inderst and Wey examine horizontal mergers.

and the question of whether bandwagoning can occur (that is, whether a first merger can increase the incentives for a second one). A final section concludes.

2 Model Set-Up

We examine an industry that has two upstream and two downstream assets. The upstream assets produce inputs that are used by downstream assets to make final goods. Inputs from at least one upstream asset are necessary for valuable production downstream. In addition, associated with each asset is a manager endowed with asset-specific human capital that is in turn necessary to generate valuable goods and services from that asset.[8] We denote the respective managers of upstream firms *A* and *B* by U_A and U_B, and downstream managers by D_1 and D_2. Integration changes the ownership of these assets; however, the manager associated with an asset will not change, as each remains necessary for its use.

An upstream asset, U_j, can produce input quantities q_{1j} and q_{2j} for D_1 and D_2, respectively. Its costs are given by $c_j(q_{1j}, q_{2j})$, assumed to be quasi-convex in (q_{1j}, q_{2j}).

Using input quantities, q_{iA} and q_{iB} from U_A and U_B, respectively, D_i makes a downstream profit (gross of payments to upstream suppliers) of $\pi_i(q_{iA}, q_{iB}, q_{-iA}, q_{-iB})$ where *-i* denotes the index of *i*'s potential downstream rival. We assume that $\pi_i(.)$ is concave in (q_{iA}, q_{iB}), non-increasing in (q_{-iA}, q_{-iB}).

Finally, it will often be convenient to express outcomes in terms of industry profits that can be generated for various supply possibilities. Let

$$\Pi(\overline{D_1 D_2 U_A U_B}) \equiv \max_{\substack{q_{1A}, q_{1B} \\ q_{2A}, q_{2B}}} \pi_1(q_{1A}, q_{1B}, q_{2A}, q_{2B}) + \pi_2(q_{2A}, q_{2B}, q_{1A}, q_{1B}) - c_A(q_{1A}, q_{2A}) - c_B(q_{1B}, q_{2B})$$

be maximized industry profits when both upstream assets can potentially provide inputs that can be used by both downstream assets. Industry profits for other supply possibilities are similarly defined. For example,

$$\Pi(\overline{D_1 U_A U_B}) \equiv \max_{q_{1A}, q_{1B}} \pi_1(q_{1A}, q_{1B}, 0, 0) - c_A(q_{1A}, 0) - c_B(q_{1B}, 0)$$

[8] This is a common set-up in the incomplete contracts literature (see, for example, Bolton and Whinston,

$$\Pi(\overline{D_1U_A}) \equiv \max_{q_{1A}} \pi_1(q_{1A},0,0,0) - c_A(q_{1A},0)$$

It is possible that a particular market structure may involve a 'partitioned' set of supply arrangements. For instance, D_1 may only negotiate with U_A and D_2 may only negotiate with U_B. In this situation, we will use the notation

$$\Pi(\overline{D_1U_A},\overline{D_2U_B}) \equiv \max_{q_{1A}} \pi_1(q_{1A},0,0,q_{2B}) - c_A(q_{1A},0)$$

$$\Pi(\overline{D_2U_B},\overline{D_1U_A}) \equiv \max_{q_{2B}} \pi_2(0,q_{2B},q_{1A},0) - c_B(0,q_{2B})$$

to denote the (equilibrium) profits to each buyer/supplier pair, respectively. The Le Châtelier principle implies that maximized industry profits are higher whenever an additional asset and its associated manager are used. For example, $\Pi(\overline{D_1D_2U_A}) \geq \Pi(\overline{D_2U_A})$ and $\Pi(\overline{D_1D_2U_AU_B}) \geq \Pi(\overline{D_1D_2U_A})$.

2.1 Timeline

The timeline for our model is as follows:

STAGE 0 (*Asset Allocation*): Ownership of assets is determined among all four managers.
STAGE 1 (*Bargaining*): Productivity parameters are revealed and bargaining over input supply terms takes place.
STAGE 2 (*Production*): Production takes place and payoffs are realized.

The asset allocation process is not modeled with a fully specified endogenous process.[9] Instead, we focus on more limited, partial incentives, including whether integration is jointly profitable for the merging parties.[10] The stage that requires further elaboration is the bargaining stage and we turn now to discuss that in detail.

1993 and Hart, 1995).

[9] Some papers do consider such issues; including Ordover, Saloner and Salop (1990). However, the externalities involved in asset allocation make a complete modeling of this process work fit for a separate paper. For an exploration of such issues see Gans (2001).

[10] We do not explicitly model any efficiency cost to integration. This could involve a straight resource costs (as in HT) or alternatively investment incentive effects (as in Hart and Moore, 1990; Bolton and Whinston, 1993). For the remainder of this paper, we simply compare the profitability of integration under different market structures, supposing that the most profitable opportunities of integration are the least likely to be outweighed by the cost of lost resources or investment.

2.2 Bargaining

Upstream and downstream firms can reach supply agreements specifying non-linear prices. Without loss of generality, we examine bargaining over supply from U_j to D_i specifying a quantity, q_{ij}, and lump-sum transfer, $\tilde{p}_{ij}$ paid by *i* to *j*. No other contracts, in particular no contingent contracts, can be written. When bargaining takes place internally, quantity is not relevant and the focus of negotiations is over the size of any transfer payment, $\tilde{t}_{ij}$ paid by *j* to manager *i* for *i*'s participation in the production process.

Our bargaining game is basically an extension of the wage bargaining model of Stole and Zwiebel (1996)—hereafter SZ – to the case of vertical supply agreements. Bargaining is pairwise, vertical (occurring between managers of individual upstream and downstream assets), and sequential (only one pair of agents bargain at a time). The order in which pairs bargain in every situation, or the probability of each order, is common knowledge. Each pair of negotiators make sequential offers to each other until they reach an agreement, and after an offer is rejected there is an infinitesimally small probability of an irrevocable breakdown in negotiations. Binmore Rubinstein and Wolinsky (1986) have proven that a pair bargaining in this fashion will agree on the Nash bargaining solution. Therefore, each pair splits the surplus resulting from an agreement relative to their expected payoffs in any renegotiation subgame that might be triggered by a disagreement.

Each pair signs a contract, but the contract is void if any subsequent bargain breaks down. The idea is that any breakdown in negotiations would radically change the supply configuration, allowing firms to invoke a clause in their contract calling for complete renegotiation after a "material change in circumstances." In other words, we are envisaging a short-run price formation process rather than negotiations over long-term supply contracts. This is an appropriate structure in environments in which price contracts are renegotiated more frequently than the market structure changes.

The key difference between our environment and SZ's is that input supply quantities are potentially variable and there is competition on both sides of the market. Their model had a single firm bargaining with many workers, each of whom supplied an indivisible unit of labor. While, as we demonstrate below, SZ's broad outcomes translate naturally to an environment without externalities (specifically, they provide a non-cooperative foundation for the Shapley value), the presence of externalities provides some complications that we outline in more detail below.

Figure 1 presents a possible sequence of bargaining negotiations for the baseline case of non-integration. Each box represents a bargaining session between a pair which can result in agreement (A) or breakdown (B). $\Gamma(.)$ denotes the subgame which takes place over the indicated sequence of pairs. Thus, $\Gamma(D_1U_A, D_2U_B, D_1U_B, D_2U_A)$ indicates a sequence of negotiations beginning with D_1-U_A, followed by D_2-U_B, D_1-U_B and D_2-U_A, respectively. If there is a breakdown in negotiations between D_2 and U_B in this sequence, the renegotiation subgame, $\Gamma(D_1U_A, D_1U_B, D_2U_A)$, is triggered. Thus, unless bargaining is between the only remaining pair, breakdowns trigger a sequence of renegotiations between all remaining pairs in the original order.[11] Consequently, when agents bargain together, they take as their disagreement payoff their expected payoff from this renegotiation game.

Because we assume that no contingent contracts can be written, subgame perfection implies that *all players take disagreement payoffs as given in their current negotiations*. Because a breakdown in negotiations is irrevocable, after a breakdown the game will never return to the current "node of the game," the set of negotiations currently underway; therefore agents cannot credibly choose a post-breakdown strategy that will improve their payoff in the current negotiations. Instead, after a breakdown they will follow the strategy that maximizes payoffs in post-breakdown negotiations.

When upstream and downstream firms are integrated – that is, their assets have a common owner – the owner negotiates over the transfer payment with the manager of each integrated asset, and the suppliers/supplies of an integrated asset negotiate with the owner. Again, the order of negotiations is common knowledge.

A final critical point to note is that the bargaining game is one of incomplete information. In particular, agents are not aware of prices and quantities agreed upon in other negotiations that they did not participate in. All they are aware of is whether an agreement or breakdown has occurred. Similarly, SZ implicitly assumed that prices were

[11] As will be demonstrated below, as in SZ, the original order does not matter for surplus generated or payoffs received. As such, it is arbitrary.

unobservable, so that prices were not a function of the bargaining order, and that agents held *passive beliefs* regarding the prices agreed upon in earlier negotiations. Under passive beliefs, an agent's beliefs about the outcomes of other negotiations are not revised by an unexpected price offer. In the vertical contracting literature, a similar assumption is made regarding quantities agreed upon by other negotiating pairs.[12] We adopt the passive beliefs assumption here with respect to both prices and quantities. The result is SZ prices, but inefficient quantities in the presence externalities.

3 Bargaining and Integration with No Externalities

In this section, we assume that there are *no competitive externalities* downstream.[13] That is, for each D_i, $\pi_i(q_{iA}, q_{iB}, q_{-iA}, q_{-iB}) = \pi_i(q_{iA}, q_{iB}, 0, 0)$ for all (q_{-iA}, q_{-iB}). This may arise if downstream firms sell distinct products using a similar set of inputs, sell products in different geographical markets, or sell highly differentiated products.[14] As will be demonstrated, this case allows us to isolate the impact of vertical integration on each agent's bargaining position – holding efficiency considerations as fixed – and provide a basis for comparing the effects of upstream competition in this regard.

3.1 Non-Integration

To build intuition, we first examine the case of non-integration when there is upstream competition. Under non-integration, all four assets are separately owned by their respective managers, who can potentially negotiate with any vertically related manager. As we will see, this is not the case under integration.

Given the assumption of passive beliefs we can solve for the equilibrium payoffs

[12] See McAfee and Schwartz (1994) for a detailed discussion.

[13] To clarify, there are still externalities between negotiations in that an agreement by one pair impacts upon upstream costs faced in another. However, we demonstrate that such externalities are internalized.

[14] This case has been a common focus of the literature on strategic vertical integration (Bolton and Whinston, 1993), the role of exclusive contracts (see, for example, Segal and Whinston, 2000) as well as competition in buyer-seller networks (Jackson and Wolinsky, 1996; Kranton and Minehart, 2001). In work contemporary with the present paper, Inderst and Wey (2002) and Bjornerstedt and Stennek (2001) also

of each agent. Moreover, we can demonstrate that the outcome is efficient in that industry profits are maximized.

Proposition 1. *In any perfect Bayesian equilibrium with passive beliefs,* $(q_{1A}, q_{2A}, q_{1B}, q_{2B})$ *are such that* $\pi_1(q_{1A}, q_{1B}) + \pi_2(q_{2A}, q_{2B}) - c_A(q_{1A}, q_{2A}) - c_B(q_{1B}, q_{2B})$ *is maximized. Each agent receives their payoff as given in Table 1.*

The proof is in the appendix. Notice that this result is independent of the precise ordering of pairs in sequential negotiations.

The intuition for efficiency is subtle, given the interactions between the negotiations of each pair of agents. As depicted in Figure 2(a), under non-integration, there are potentially four pairs of negotiations. Each negotiation involves Nash bargaining where the pair chooses their respective supply quantity to maximize their bilateral payoff. For example, U_A and D_1 would choose $(\tilde{p}_{1A}, q_{1A})$ to maximize:

$$\left(\pi_1(q_{1A}, q_{1B}) - \tilde{p}_{1A} - \tilde{p}_{1B} - \Phi_{1A}\right)\left(\tilde{p}_{1A} + \tilde{p}_{2A} - c_A(q_{1A}, q_{2A}) - \Phi_{A1}\right) \tag{1}$$

where Φ_{ij} and Φ_{ji} represent the payoffs D_i and U_j expect to receive in the renegotiation subgame triggered by a breakdown in their negotiations; by subgame perfection, these are taken as given. The remaining pricing terms either form the subject of a previous agreement earlier in the bargaining sequence (in which case their terms are given by the assumption of passive beliefs) or anticipate the negotiations of pairs further in the sequence. In that case, we can demonstrate that when anticipated outcomes are substituted into (1), the only term involving q_{1A}, taking into account the envelope theorem, is a linear function of $\pi_1(q_{1A}, q_{1B}) - c_A(q_{1A}, q_{2A})$. Thus, q_{1A} is always chosen to maximize industry profits.

In terms of distribution, the equilibrium payoffs in Table 1 represent the Shapley values of each respective agent given the allocation of assets among them. This mirrors the finding of SZ.[15] While other analyses of bilateral oligopoly have derived Shapley value outcomes in their relevant bargaining game ours differs in two respects. First, it is

provide an analysis of the no competitive externalities case under conditions of bilateral oligopoly.

[15] A similar type of result drives Stole and Zwiebel (1998). Their paper considers the impact of a horizontal merger amongst non-competing firms on intra-firm bargaining with workers. A horizontal merger means that workers connected previously to one another through two firms, will be connected directly to the merged entity. Stole and Zwiebel (1998) show that this may improve or harm their bargaining position depending upon the nature of cost savings from the merger.

based on sequential rather than simultaneous bargaining. Second, given this, we do not require supply agreements to specify pricing arrangements that would arise for every industry configuration. For example, Inderst and Wey (2002) require price and quantity agreements to be arrived at for every possible series of breakdowns that may emerge. In contrast, we do not allow negotiating agents to commit to supply arrangements contingent on the exit or severing of any supply relationship in the industry.

3.2 Vertical Integration

Vertical integration involves a change in asset ownership between an upstream and a downstream manager. We will focus here on vertical integration between U_A and D_1. This may involve forward integration (FI) whereby U_A acquires D_1's assets or backward integration (BI) where U_A's assets are acquired by D_1.[16] In each case, as in the property rights literature, the acquirer becomes the residual claimant to the earnings of an asset and has residual control rights as to what it is used for (Grossman and Hart, 1986; Hart and Moore, 1990). However, each manager continues to be essential for the productive use of the asset.

To illustrate what changes in ownership mean in the present context, suppose U_A integrates forward by purchasing D_1's assets. The manager of the acquired D_1 receives a transfer payment, $\tilde{t}_{1A}$, while the profits from its asset, $\pi_1(q_{1A}, q_{1B}) - \tilde{t}_{1A} - \tilde{p}_{1B}$, accrue to the new owner, U_A. Importantly, as depicted in Figure 2(b), U_A rather than D_1 negotiates a supply agreement with U_B for the supply of inputs to D_1. This is because the residual control rights of the downstream asset have been transferred to U_A. Thus, in the event of a breakdown in negotiation between U_A and the manager of D_1 or U_A and U_B, no supply will occur between U_B and D_1.

What this means is that a breakdown between U_A and the manager of D_1 has a deeper impact upon U_B and D_2. While, under non-integration, such a breakdown would still mean that D_1 could continue to operate receive supply from U_B, under FI, this would no longer occur. In this case, U_B would be left with D_2 as its sole source of demand. FI

[16] There is a third option characterized by some form of joint ownership. As there is an issue with regard to how that form of ownership might operate in this setting (see Bolton and Whinston, 1993), we do not consider it here.

thus eliminates U_B being the only supplier of D_1; thereby, weakening its bargaining power. For the same reason, FI improves the bargaining position of D_2 as it increases the chances it will not have to compete with D_1 for U_B's input.

Nonetheless, in this environment, it can be demonstrated – along the same lines as the proof of Proposition 1 – that integration (BI or FI) will only impact upon the distribution of surplus between agents and not on the overall surplus generated. As in non-integration, this occurs because, under passive beliefs, each negotiating pair chooses its respective quantity in a way that does not impact on the pricing and quantity terms of other negotiations. Thus, the supply quantities chosen continue to maximize industry profits.

Each agent's payoffs change, however. Those payoffs are contained in Table 1. The critical feature to note about the effects of integration is that it rules out the participation of an asset's manager from a coalition that does not include the owner. When U_A owns D_1 (that is, forward integration FI), the payoff $\Pi(\overline{D_1 D_2 U_B})$ becomes $\Pi(\overline{D_2 U_B})$, and the payoff $\Pi(\overline{D_1 U_B})$ becomes $\Pi(\overline{U_B}) = 0$. When D_1 owns U_A (that is, backward integration BI), the payoff $\Pi(\overline{D_2 U_A U_B})$ becomes $\Pi(\overline{D_2 U_B})$, and the payoff $\Pi(\overline{D_2 U_A})$ becomes $\Pi(\overline{D_2}) = 0$. In each case, integration diminishes the bargaining position of one or both of the non-integrated firms and, as is depicted in the last two rows of Table 1, this raises U_A and D_1's joint payoff from integration over non-integration by $\frac{1}{6}\left(\Pi(\overline{D_1 D_2 U_B}) - \Pi(\overline{D_2 U_B})\right)$ for FI and $\frac{1}{6}\left(\Pi(\overline{D_2 U_A U_B}) - \Pi(\overline{D_2 U_B})\right)$ for BI.

Comparing these two changes in payoff, notice that FI will be chosen over BI if and only if $\Pi(\overline{D_1 D_2 U_B}) > \Pi(\overline{D_2 U_A U_B})$. That is, FI is favoured as an instrument for improving joint bargaining power precisely when upstream firms are closer substitutes than downstream firms.[17] In other words, the acquiring firm comes from the *more* competitive vertical segment. This is precisely because integration eliminates an option for the acquirer's competitor, an option that is valuable precisely because firms in the other vertical segment are not close substitutes (and therefore that segment is less competitive). For example, forward integration means that U_B loses an option to supply both downstream firms and this loss is costly when supplying both is relatively valuable. Consequently, the non-integrating firm that suffers the greatest harm from integration is the firm that is in the same segment as the acquiring firm (i.e., D_2 under BI and U_B under FI).

Importantly, our results here generalise HT's 'scarce needs' and 'scarce supplies' motives for vertical integration, by allowing for upstream costs to lie between the extremes of constant and L-shaped marginal costs. To see this, observe that when upstream marginal costs are constant and symmetric (that is, there are 'scarce needs' as industry supply is perfectly elastic), D_1 and U_A have no incentive for BI but a positive incentive for FI. In this case, D_2's payoff is unchanged and rents shift entirely from U_B. In contrast, when upstream firms are capacity constrained and downstream firms are perfectly substitutable[18] (that is, there are 'scarce supplies'), there is no incentive for FI but a positive incentive for BI. In that case, it is U_B's payoff that is unchanged by integration with the impact being borne entirely by D_2. This accords with the general findings of HT.[19] However, we have derived these motives for vertical integration in a model where bargaining position is determined by the characteristics of possible breakdown market structures rather than an exogenous parameter. We demonstrate below that these motives are preserved when competitive externalities are considered.

3.3 Upstream Monopoly

As the focus of this paper is the change in the effect of vertical integration as upstream competition is introduced, we need to take care in specifying the upstream monopoly case.[20] In particular, we require the set of productive assets in the industry to be the same between the two cases as well as the characteristics of any human capital.

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[17] As $\Pi(\overline{D_2U_AU_B}) \rightarrow \Pi(\overline{D_2U_j})$

[18] In the no externalities case, this would arise if $\partial\pi_i / \partial q_{ij}$ were constant for any quantity smaller than total upstream capacity. In HT, they assume that downstream outputs are perfect substitutes that also make those firms perfect substitutes. We consider this case in Section 4 below.

[19] Strictly speaking, while HT find that only D_2 is harmed under 'scarce supplies,' in their 'scarce needs' model both non-integrated firms were harmed by integration. In our model, when upstream costs lie between these two extremes, we also find the both D_2 and U_B are harmed by integration.

[20] All of the results regarding vertical integration in this sub-section would similarly hold if we had a downstream monopsony rather than upstream monopoly. There would, however, be a difference in results

This means that we cannot simply take the two upstream assets and combine them under a single owner, as one of the assets will be managed by an individual with important human capital. As with vertical integration, that agent cannot be replaced and so will have some bargaining power in negotiations with the owner of upstream assets.

The only difference between the outcomes under upstream monopoly as compared with upstream competition is in the distribution of the surplus between agents. Industry profits are maximized under the same logic as Proposition 1 and these profits are the same as under upstream competition, as the characteristics of resources in the industry are unchanged. In contrast, the payoffs of individual agents – listed in Table 1 – are different under upstream monopoly.

The negotiating relationships for upstream monopoly are depicted in Figure 3(a). In comparison with the upstream competition case, there are only three relevant negotiations as there is only a single firm negotiating the supply of inputs to downstream firms. What this means is that if negotiations between the upstream monopolist (chosen to be U_A) and a downstream firm break down, the downstream firm exits the industry.

As before, we consider vertical integration between U_A and D_1. The changed bargaining relationships are depicted in Figures 3(b) and 3(c) for the cases of forward and backwards integration, respectively. Notice that, under forward integration, the change in residual control rights implies no change in the bargaining relationships. This means that forward integration will yield *exactly* the same payoffs as non-integration.

In contrast, the changes in bargaining relationships under backwards integration are quite extensive (see Figure 3(c)). In this situation, D_1 purchases U_A's assets. This makes D_1 the owner of its assets and those of U_A and U_B. It will negotiate with *both* of those managers. Hence, backwards integration allows some market structures to be possible relative to the non-integration case. In particular, it is now possible for D_1 to rely solely on supply from U_B, because U_B's manager can still supply D_1 if negotiations break down between D_1 and U_A's manager. The implication is that BI may improve U_B's bargaining position.[21]

Backward integration is preferred to the status quo — or, equivalently, FI — if

when we include competitive externalities downstream.

[21] For example, when U_A and U_B are perfect substitutes (i.e., symmetric with linear costs), U_B obtains no

$\Pi(\overline{D_2U_AU_B}) > \Pi(\overline{D_1D_2U_B})$; this is the same condition as under upstream competition. In other words, BI is preferable if upstream assets are relatively less substitutable than downstream assets. Otherwise, BI may not be privately desirable as it improves the bargaining power of U_B whose productive role is otherwise similar to U_A. Thus, as in the upstream competition case, the acquiring firm comes from the segment that is relatively competitive, and not the monopoly segment as is the presumption of conventional wisdom.

3.4 Comparison of Upstream Competition and Upstream Monopoly

We are now in a position to compare the incentives for vertical integration in upstream monopoly with those for upstream competition, based on pure bargaining effects. Recall that the payoff to FI relative to BI is determined by the same condition in upstream monopoly and upstream competition; so we can look at FI and BI in turn, using the results in Table 1.

For FI, the comparison is clear: there is no incentive for FI under upstream monopoly, but a positive incentive for FI under upstream competition. FI confers additional market power on the upstream firm, by ruling out options for the other upstream firm; but under upstream monopoly, this has already been achieved.

For BI, it is easy to see that it too will improve the joint payoff to U_A and D_1 by more under upstream competition than under upstream monopoly, as $\Pi(\overline{D_1D_2U_B}) \geq \Pi(\overline{D_2U_B})$. The role of BI is to eliminate the possibility of a D_2 monopsony facing the upstream firms. Under upstream competition, BI only increases the chance of a bilateral monopoly between U_B and D_2, whereas under upstream monopoly the possibility of a U_B monopoly is reintroduced.

Thus, from a pure bargaining perspective, *integration has a higher private return under upstream competition than from upstream monopoly*. The reason for this is that the benefits of integration flow from harming agents outside of the proposed merger, thereby redistributing rents in favour of the insiders. Under upstream monopoly, outsiders either do not have their bargaining position change, or in some cases can potentially improve

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rents under non-integration and positive rents under backwards integration.

their negotiating relationships with insiders. For upstream competition, integration always removes possible market structures that may have been of benefit to outsiders. Hence, the incentive for integration is stronger under upstream competition. If vertical integration involved a fixed cost (in terms of foregone investment, or transactions costs), integration would be more likely under upstream competition.[22]

4 Competitive Externalities

The previous section demonstrates that incentives for strategic vertical integration can be higher under upstream competition than upstream monopoly. In the no externalities case, however, total surplus is unchanged following integration; industry profits are always maximized. However, integration altered the distribution of surplus in ways that were different, depending up the degree of upstream competition. When there are competitive externalities, the distributional (or bargaining) consequences of vertical integration are largely preserved. What differs is the level of total profits and therefore, integration has welfare consequences. As we demonstrate in this section, vertical integration can lead to higher downstream prices and increased deadweight losses, as in the contracting externalities literature. Critically, however, the industry profits generated by vertical integration differ between upstream competition and monopoly. In this section, we explore how the presence of upstream competition impacts upon the extent any welfare losses from integration.

4.1 Total Surplus

The contracting externalities literature typically considers a monopolist selling to downstream firms producing identical goods.[23] The monopolist makes take-it-or-leave-it offers to each firm in turn. If it were to sell the profit-maximizing quantity to the first, it would have an incentive to "secretly discount" (i.e., sell more than the profit-maximizing

[22] Given that the payoffs of at least one non-integrated firm is being reduced by integration, there is also a possibility that integration may induce exit. In this case, there will be a direct welfare consequence of integration. This is the primary focus of HT; however, here we have specified a model and assumed that exit does not occur. That extension of the present model is left for future work.

quantity, at a discount) for other downstream firms, as those later offers would not internalize any externality imposed on contracts already signed. For this reason, firms will not accept a contract consistent with industry profit maximization. If prices and quantities are unobservable, and if agents hold *passive beliefs*, implying that they do not revise their beliefs about prices and quantities in other contracts when they observe behavior that is off the equilibrium path, the only perfect Bayesian equilibrium is for the monopolist to offer Cournot quantities to all firms. In other words, each negotiating pair maximizes their profits, taking the negotiated quantity in the other agreement as given.

A similar set of outcomes arises in our bargaining environment. Bilateral Nash bargaining implies that each q_{ij} is chosen to maximize $\pi_i(.) - c_j(.)$, taking as given quantities chosen in other negotiations (by passive beliefs). When there were no competitive externalities, this choice did not impact upon the outcome of other negotiations; therefore each choice maximized industry profits. Similarly, in market structures where only one downstream firm is present, industry profits will still be maximized, as there are no competitive externalities. However, total industry profits will not be maximized overall when both downstream firms are present, as each negotiation imposes externalities on others. Let $\hat{\Pi}(.)$ represent equilibrium industry profits in that case. The following proposition summarises the equilibrium outcome:

Proposition 2. *There exists a perfect Bayesian equilibrium with passive beliefs, under non-integration, regardless of whether there is upstream competition or monopoly, in which* $\hat{\Pi}(\overline{D_1 D_2 U_A U_B})$, $\hat{\Pi}(\overline{D_1 D_2 U_A})$ *and* $\hat{\Pi}(\overline{D_1 D_2 U_B})$ *are at their Cournot duopoly levels when upstream inputs are supplied at a price equal to industry upstream marginal cost. For all other structures,* $\hat{\Pi}(.) = \Pi(.)$.

As we do not rule out quantity commitments, our model yields the same conclusion reached in the contracting externalities literature, that under passive beliefs, Cournot outcomes will result. What is interesting here is that this is achieved despite the fact that there are two upstream firms, yielding the same outcome (most notably productive efficiency)[24] as if there were a single upstream firm. Interestingly, this implies that an

[23] See HT, Rey and Tirole (1997), O'Brien and Shaffer (1992) and McAfee and Schwartz (1994).

[24] That is, suppose, as do HT, that both upstream firms have constant marginal costs but that U_B's is higher than U_A's. In this case, under upstream monopoly, U_A would never choose to supply using the other upstream asset. And under upstream competition, the Cournot equilibrium would involve supply purely

upstream merger does not change retail prices and welfare downstream in this setting.[25] Because there is no negotiation involving residual claimants on the returns of both downstream assets, there is no negotiation where the impact of a supply choice on both firms is considered. Instead, in each negotiation the quantity of one downstream firm is chosen holding that of the other constant – yielding a Cournot equilibrium.

EXAMPLE: *Suppose that both downstream firms face linear demand,* $p_i = 1-(q_{iA}+q_{iB})-\gamma(q_{-iA}+q_{-iB})$ $(1 \geq \gamma)$ *and have cost functions* $c_i(q_{iA},q_{iB}) = \theta(q_{iA}-q_{iB})^2$ *(with* $1 \geq \theta \geq 0$*) while upstream firms (j = A or B) have symmetric cost functions,* $c_j(q_{1j}+q_{2j}) = (q_{1j}+q_{2j})^2$*. The unique equilibrium under both upstream competition and monopoly involves both downstream firms being supplied* $\hat{q}_{ij} = \frac{1}{8+2\gamma}$ *by both upstream firms generating profits of* $\hat{\Pi}(\overline{D_1 D_2 U_A U_B}) = \frac{4}{(4+\gamma)^2}$*; which is, of course, greater than the fully integrated monopoly outcome of* $q^*_{ij} = \frac{1}{8+4\gamma}$ *with* $\Pi(\overline{D_1 D_2 U_A U_B}) = \frac{1}{4+2\gamma}$*. Similarly, in this situation,* $\hat{\Pi}(\overline{D_1 D_2 U_j}) = \frac{2(3+\theta)}{(6+2\theta+\gamma)^2}$ *is generated by an interior solution with* $\hat{q}_{ij} = \frac{1}{6+2\theta+\gamma}$.

What happens when D_1 and U_A integrate? First, as in the no externality case, this eliminates certain market structures depending upon whether there has been FI or BI. Second, for those market structures that remain possible, equilibrium industry profits are unchanged for all market structures where one or more of D_1, D_2 and U_A are not present. That is, a change in equilibrium profits following integration requires the presence of both D_1 and U_A, and it is only where D_2 is also present that industry profits are not necessarily maximized under non-integration and integration alike.

Third, the impact on equilibrium outcomes from integration is the same under both BI and FI. In each case, integration implies that the residual claimant on the profits of D_1 is the one negotiating the supply from U_A to D_2. Under both FI and BI, in negotiations over q_{2A}, the negotiated supply quantity maximizes $\pi_1(.)+\pi_2(.)-c_A(.)$. This is because the residual claimant on D_1's profits negotiates with D_2 over the supply from U_A to D_2. Nonetheless, negotiations that are internal to the integrated firm will still involve supply quantities chosen to maximize $\pi_i(.)-c_j(.)$. D_2 does not participate in

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from U_A and none from U_B. As we demonstrate below, however, in contrast to the conclusion of HT, U_B may still be paid in equilibrium.

[25] If there were externalities amongst upstream firms, this would no longer be the case.

those negotiations and hence, the impact on its profits is not considered.

Fourth, there is a difference between the impact of integration in the upstream competition and monopoly cases. Under upstream competition, negotiations over q_{2B} will still maximize $\pi_2(.) - c_B(.)$ whereas, under upstream monopoly, $\hat{q}_{2B} \in \arg\max_{q_{2B}} \pi_1(.) + \pi_2(.) - c_B(.)$. The fact that competitive externalities are internalized in two negotiations rather than one suggests that integration will allow an upstream monopolist to more easily restrict output and raise prices downstream. Given the general nature of profit and cost functions (and potential asymmetries between firms) assumed thus far, it is not possible to provide a simple proof of this.

Nonetheless, by imposing further restrictions, we can characterise the effects of integration on industry profits explicitly.

Proposition 3. *Let* $\hat{\hat{\Pi}}_{UC}(.)$ *and* $\hat{\hat{\Pi}}_{UM}(.)$ *denote industry profits in any perfect Bayesian equilibrium with passive beliefs under integration by* D_1 *and* U_A, *for upstream competition and monopoly respectively. Assume that (1)* D_1 *and* D_2 *are symmetric and indifferent as to the source of input supply; and (2) each* c_j *has symmetric and weakly concave isoquants (for given total cost) in* (q_{1j}, q_{2j}). *Then*

(i) $\hat{\hat{\Pi}}_{UC}(\overline{D_1 D_2 U_A U_B}) = \hat{\Pi}(\overline{D_1 D_2 U_A U_B})$;

(ii) If D_1 *and* D_2 *sell products that are perfect substitutes, then* $\hat{\hat{\Pi}}_{UM}(\overline{D_1 D_2 U_A U_B}) = \Pi(\overline{D_1 D_2 U_A U_B})$ *and* $\hat{\hat{\Pi}}_{UM}(\overline{D_1 D_2 U_A}) = \hat{\hat{\Pi}}_{UM}(\overline{D_1 D_2 U_A}) = \Pi(\overline{D_1 D_2 U_A})$.

Proposition 3 provides a sharp characterization of the outcomes in an environment where upstream competition is very strong (as upstream inputs are perfectly substitutable from the point of view of downstream firms). The concavity of upstream cost isoquants means that it is cost minimizing for each upstream firm to supply a single downstream firm, under non-integration as well as integration.[26] In the presence of upstream competition, therefore, all integration does is select who will supply whom, without changing the actual surplus generated.[27] This leads to the interesting result that if a dedicated supply flow is optimal, there is no change in industry profits following integration (Result (i)).

[26] Proposition 2 demonstrates that cost minimization is achieved in equilibrium.

[27] HT's ex post monopolization case similarly found that there was no increase in industry profits following integration. This was because their case is a special case of Proposition 3 with linear isoquants.

When downstream firms are perfect substitutes, we can further characterize the results. When there is an upstream monopolist– either U_A and U_B are owned by the same manager, or U_B has exited the market following breakdowns in negotiation, leaving U_A alone in the market –integration leads to *foreclosure* of the non-integrated firm, D_2. The monopoly quantity is supplied to D_1, and profits are thereby maximized.[28] It is important to note, however, that while it appears that foreclosure occurs here – as the independent downstream firm receives no inputs from its integrated rival, this does not necessarily mean that D_2 is not paid by that integrated firm; a point we discuss in more detail when we consider the distribution of surplus below.[29]

When D_1 and D_2 are not perfect substitutes, upstream firms reduce their supply to D_2 but do not necessarily foreclose. This is precisely the monopolization effect from integration first identified by HT that arises because the integrated firm internalizes its own competitive externality when negotiating with outside parties. Industry profits are not perfectly maximized, in general, because the integrated firm does not take into account the externality it imposes on D_2; something borne out in our running example.

When it comes to integration under upstream competition, however, the impact of integration on overall profits is, in general, ambiguous. The main reason for this is that, while an upstream monopolist will necessarily take actions that realize productive efficiency for upstream supply, there is no similar control in upstream competition. While this did not matter under non-integration, integration, by creating incentives for U_A to reduce its supply to D_2, creates the opposite incentives for U_B, who wants to expand supply to D_2. If downstream firms care about the source of input supply (i.e., do not view outputs from U_A and U_B as perfect substitutes), then these changes can increase industry costs and lead to a reduction in profits; a possibility we demonstrate in our running example below.

EXAMPLE (Continued): *When* $\theta = 0$ *(downstream firms are indifferent as to the source of input supply), vertical integration does not change the equilibrium outcome under upstream competition (as this involved each upstream firm supplying a single downstream firm); although* U_A *will be the sole supplier of* D_1 *(thus,*

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[28] Proposition 3 is stated more strongly that necessary, on this point: no assumptions on upstream firms are necessary. It is only necessary for downstream firms to be perfect substitutes.

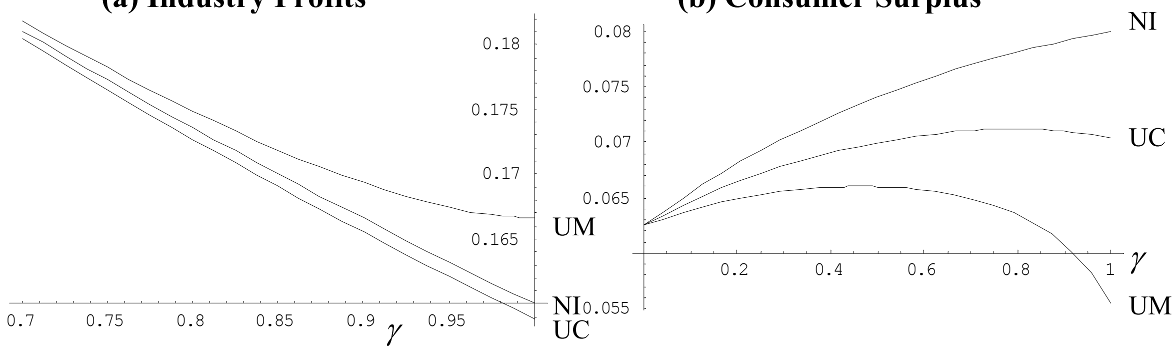
[29] HT also find similar supply flows and industry profit outcomes as in Proposition 3. However, as will be discussed below, we do not find that this means that D_2 is foreclosed in the traditional sense and forced to exit the industry.

$\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B}) = \hat{\Pi}(\overline{D_1D_2U_AU_B})$). *For upstream monopoly, as all supply is controlled by the owner of D_1, the impact of any supply to D_2 on D_1's profits will be internalised for that decision. In addition, it is easy to confirm that both downstream firms will continue to be supplied (each from one downstream asset); although there will be a contraction of supply to D_2 relative to the non-integrated case (thus,* $\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B}) = \frac{32-40\gamma+7\gamma^2+4\gamma^3}{2(2\gamma^2+3\gamma-8)^2}$*).*

When $\theta > 0$, integration changes industry profits under both upstream monopoly and upstream competition. In each case, there is an overall reduction in output with D_1 having a higher output than D_2. The following Figure 4(a) shows what happens to industry profits in this case and Figure 4(b) shows what happens to consumer surplus. Note that $\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B}) > \hat{\Pi}(\overline{D_1D_2U_AU_B}) > \hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})$ *(for θ high enough) while for consumer surplus non-integration provides the best outcome and integration by an upstream monopolist is the worst. Overall total welfare follows the consumer surplus ranking. Nonetheless, consumers in D_1's (D_2's) market are better (worse) off under integration with an upstream monopoly than the upstream competition case.*

Figure 4
($\theta = 1$)

(a) Industry Profits **(b) Consumer Surplus**[30]



4.2 Distribution

In solving for the equilibrium payoffs under competitive externalities, there arises the important issue of what SZ term '*feasibility*.' An equilibrium is feasible if there is no incentive for an individual party to precipitate a breakdown in any negotiating pair at any stage (i.e., in any market structure that might have emerged). Under competitive externalities feasibility cannot be guaranteed.

To see this, consider a situation where a single upstream firm, U_A, is negotiating with two non-integrated downstream firms. If both negotiating pairs agree then they

[30] Defined as the unweighted sum of consumer surplus generated from both downstream products.

divide up $\hat{\Pi}(D_1D_2U_A)$ with:

$$v_{U_A} = \tfrac{1}{6}\left(2\hat{\Pi}(D_1D_2U_A) + \Pi(D_1U_A) + \Pi(D_2U_A)\right),$$
$$v_{D_1} = \tfrac{1}{6}\left(2\hat{\Pi}(D_1D_2U_A) + \Pi(D_1U_A) - 2\Pi(D_2U_A)\right),$$
$$v_{D_2} = \tfrac{1}{6}\left(2\hat{\Pi}(D_1D_2U_A) - 2\Pi(D_1U_A) + \Pi(D_2U_A)\right).$$

However, suppose that U_A negotiated with D_1 followed by D_2, then by refusing to negotiate with D_1 and causing an eventual breakdown, U_A would receive $\tfrac{1}{2}\Pi(D_2U_A)$ from an agreement with D_2 alone. If $\Pi(D_2U_A) - \tfrac{1}{2}\Pi(D_1U_A) > \hat{\Pi}(D_1D_2U_A)$, both U_A and D_1 would prefer a breakdown to an agreement and hence, an equilibrium involving both downstream firms being active would not be possible. Observe that this preference would not occur in the absence of externalities; hence feasibility is not an issue in that case.

Importantly, note that, in contrast to other papers on competitive externalities such as Hart and Tirole (1990), Rey and Tirole (1997) and Chemla (2002), we allow the upstream firm to exclude one downstream firm or the other. What constrains the incentive to exclude, however, is that after triggering a breakdown the upstream firm would face only a single downstream firm, with greater bargaining power as a result. The upstream firm trades off competitive externalities against the loss in bargaining power.

For the remainder of this paper, we will assume that the feasibility conditions hold regardless of the level of integration. Nonetheless, in the appendix, we provide the full conditions for feasibility to hold in our model (including our running example).

Given feasibility, we can demonstrate the following:

Proposition 4. *In any perfect Bayesian equilibrium with passive beliefs, each firm receives the payoffs listed in Table 2.*

The payoffs in Table 2 are particularly interesting: they are not classical Shapley values. For example, payoffs are a function of $\hat{\Pi}(\overline{D_1U_A}, \overline{D_2U_B})$, the profit earned by U_A and D_1 jointly when U_A supplies D_1, and they face competing supply in the downstream market from D_2, supplied by U_B. In contrast, Shapley values do not allow one's payoff to depend on the configuration of players that one is not cooperating with. In effect these payoffs are allowing for the effect of competitive externalities. Notice that when there are no externalities, the payoffs in Table 2 collapse to Shapley values (as in Table 1); that is, profits are maximized under all market structures and, say, $\hat{\Pi}(\overline{D_1U_B}, \overline{D_2U_A}) = \Pi(\overline{D_1U_B})$.

Notice, however, that the Shapley value-type solution arises naturally in the upstream monopoly case. In that situation, U_B can never produce independently of U_A, so the types of partitions that arise for the upstream competition case are ruled out. Thus, distribution with competitive externalities does not change the payoffs of each agent; save for the fact that industry profits are not maximized where both downstream firms are present.

4.3 Comparing Incentives for FI and BI

In Section 3, we asked whether the acquiring firm in vertical integration would come from the more or less competitive vertical segment. From Table 2, we can see that FI will be preferred to BI, under either upstream competition or monopoly, if and only if $\hat{\Pi}(\overline{D_1D_2U_B}) \geq \Pi(\overline{D_2U_AU_B})$. This corresponds to the comparison made for the no externalities case except that here the left hand side takes into account the fact that when downstream outputs are substitutes in the eyes of consumers, industry profits will be lower as a result of their competition. Indeed, the more substitutable are downstream outputs in the eyes of consumers (intensifying Cournot competition under non-integration), the more likely it is that a downstream firm will acquire upstream assets. Hence, our conclusion that the acquirer will come from the more competitive vertical segment is strengthened when there are competitive externalities.

4.4 Comparing Upstream Competition and Monopoly

The central question being considered in this paper is whether it is indeed the case that there is more incentive for vertical integration when there is upstream monopoly rather than upstream competition. When there are no competitive externalities, we concluded that due to pure bargaining effects, the greatest potential for purely strategic vertical integration arose under upstream competition than upstream monopoly.

When there are competitive externalities, vertical integration involves a monopolization effect and consequent welfare harm. In the special case of Proposition 3, this effect was stronger when there was a vertically integrated upstream monopolist rather than an upstream competitor. Nonetheless, using Table 2, we can compare the incentives for welfare-reducing vertical integration in each case.

Proposition 5. *The increase in the joint payoff of D_1 and U_A from both FI and BI under upstream competition will exceed that achieved under upstream monopoly if and only if* $\frac{1}{3}\left(\hat{\Pi}(\overline{D_1 D_2 U_B}) - \Pi(\overline{D_2 U_B})\right) \geq \hat{\hat{\Pi}}_{UM}(\overline{D_1 D_2 U_A U_B}) - \hat{\hat{\Pi}}_{UC}(\overline{D_1 D_2 U_A U_B})$.

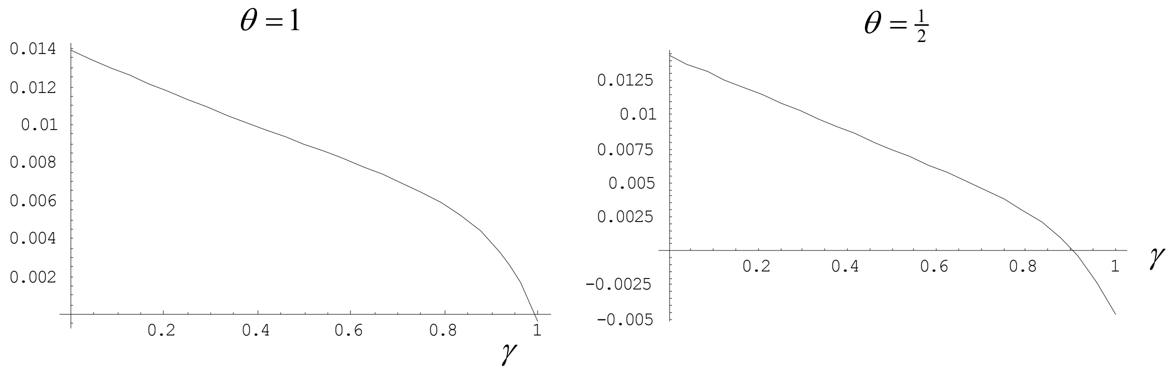
The left hand side of the inequality in the proposition comes from the fact that the bargaining effect from vertical integration is stronger under upstream competition than monopoly. On the other hand, an upstream monopoly is able to use vertical integration more effectively to increase industry profits; thus, the monopolization effect weakens the relative incentives of an upstream competitor to vertically integrate.

Propositions 3 and 5 demonstrate that if downstream firms sell perfectly substitutable products, the conventional wisdom regarding the impact of upstream competition on the incentive to integrate is likely (although not guaranteed) to hold. In that case, the left hand side of the inequality in Proposition 5 is at its lowest while the right hand-side is at its highest possible level; as the upstream monopolist can achieve an industry monopoly outcome when it integrates while under upstream competition, integration leaves industry profits unchanged.

Nonetheless, as downstream products become less substitutable, it is likely that the reverse will be the case. Indeed, we know (from Section 3) that in the extreme – where downstream firms operate in separate markets – there is a greater incentive to integrate under upstream competition. This suggests that as the degree of downstream product differentiation becomes sufficiently high, the conventional wisdom will be overturned. For our running example we can demonstrate that this is indeed the case.

EXAMPLE (Continued): *Figure 5 illustrates the difference between the incentives for vertical integration under upstream competition less those under upstream monopoly. Note that the lower the degree of product differentiation, the lower is the relative incentive under upstream competition.*

Figure 5: Differences in the Payoff Increase from Integration under Upstream Competition and Monopoly



4.5 Integration and Foreclosure

It is worth emphasizing that the foreclosure effects of integration on non-integrated firms differ in a subtle but important way from previous studies. An interesting feature of the upstream monopoly case is that, under the assumption of perfect symmetry and substitutability upstream and downstream, vertical integration leads to the monopoly output industry-wide. In that case, D_2 is not supplied any inputs and hence, does not produce, leaving D_1 to supply the monopoly quantity downstream. However, under FI, D_2 does receive a payoff of:

$$v_{D_2}(FI) = \tfrac{1}{12}\left(\Pi(\overline{D_1 D_2 U_A U_B}) - \Pi(\overline{D_i U_j})\right).$$ [31]

The reason for this is that even though D_2 plays no actual productive role, it does provide both the independent upstream firm and the integrated firm (in its internal negotiations under FI) with an outside option in case of a bargaining breakdown with D_1.[32] Thus, while there is *technical* foreclosure in terms of the elimination of downstream competition, U_A still cedes rents to D_2 so as to improve its bargaining position with respect to D_1's manager.[33]

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[31] Note that, under BI, for this example, feasibility is not satisfied for negotiations with D_2, who would prefer to exit the industry.

[32] It might be supposed that a lump sum payment from upstream firms to D_2, without any corresponding input supply might be seen as strange. The solution here can be approximated, however, by some arbitrarily small input supply to D_2.

[33] When upstream firms have constant costs (as in HT's 'Ex Post Monopolisation' variant) but, say, U_A's costs are lower than U_B's, then U_B does not supply either downstream firm under non-integration or integration. However, while in HT, this implies that U_B receives no payoff, here that is only the case under

5 Bandwagon Effects

An important issue in studies of vertical integration (Chandler, 1964 and Scherer, 1980) is whether vertical integration by one set of firms in an industry might enhance incentives for other firms to integrate. That is, is there a bandwagon effect associated with vertical integration?

The literature is divided on this issue. Some researchers examining the possibility of vertical foreclosure have constructed models whereby vertical integration reduces incentives for further integration. For instance, Ordover, Saloner and Salop (1990) argue that initial integration is driven by competition for assets and the negative externality of integration on non-integrated firms, something not present for later integration choices. Choi and Yi (2000) similarly demonstrate that potential negative externalities motivating initial integration are not present for later integration as such integration may 're-symmetrize' competition and trigger a strong competitive response. In contrast, HT and McLaren (2000) provide models whereby initial integration raises the incentives for further vertical integration. In each case, vertical integration exacerbates potential 'hold-up' problems faced by non-integrated firms and may drive them to integrate.

Our approach here does not consider an asset market effect nor rely on the potential for vertical integration to resolve hold-up problems. In contrast, bandwagon effects are driven by bargaining and monopolization considerations. To see this, suppose that following forward or backwards integration by U_A and D_1, U_B and D_2 integrate in the same fashion.[34]

Under upstream monopoly, if one downstream firm is already integrated with the upstream firm, then further integration of the other pair will not change the bargaining position of any agent. Neither the flow of possible negotiation relationships nor the outside options of any agent change following this ownership change. Integration can

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upstream monopoly. Under upstream competition, so long as U_B is not too inefficient, U_B receives a payment from D_1 (or the integrated firm) so as it improve its bargaining position in the event of an internal breakdown. However, it always receives a payment from D_2. Hence, even with FI, U_B may not wish to exit the industry.

[34] As before, we need to make an assumption as to what would happen if negotiations broke down between the downstream unit of one firm and the other integrated firm. Analogous to our earlier assumption, we assume that in this case, no negotiations between the two firms would be possible – that is, the downstream unit of the other firm would not be able to purchase inputs outside their firm.

only serve to further monopolize the market, and then only in the case where downstream products are not perfect substitutes (by Proposition 3).

Turning to the upstream competition case, the payoffs following a second merger are as in Table 3. From this, we can demonstrate the following:[35]

Proposition 6. *Let NI, A1, B2 and CI denote the states of non-integration, integration by U_A and D_1, integration by U_B and D_2 and integration by both pairs, respectively. Let* $\Lambda \equiv \frac{1}{2}\left(\hat{\Pi}_{CI}(D_1D_2U_AU_B) - \hat{\Pi}_{B2}(D_1D_2U_AU_B) - \hat{\Pi}_{A1}(D_1D_2U_AU_B) + \hat{\Pi}_{NI}(D_1D_2U_AU_B)\right)$. *Then the increase in the joint payoff to U_B and D_2 from BI is Λ higher if it occurs after U_A and D_1 have integrated. The increase in the joint payoff to U_B and D_2 from FI is* $\Lambda + \frac{1}{6}(\hat{\hat{\Pi}}_{A1}(D_1D_2U_A) - \hat{\Pi}_{NI}(D_1D_2U_A))$ *higher if it occurs after U_A and D_1 have integrated.*

Significantly, this means that if neither the first or second merger changes overall industry profits, then there is no bandwagon effect; indeed, U_B and D_2's incentives to merge are unchanged by what U_A and D_1 may have done. The reason is that, in these cases, the only impact from vertical integration comes from bargaining effects. Recall that integration serves to rule out possible industry configurations following negotiation breakdowns. Specifically, BI between U_B and D_2 rules out $(\overline{D_1D_2U_A})$ while FI rules out $(\overline{D_1U_AU_B})$, and these two payoffs are unaffected by a merger between U_A and D_1;[36] the increment to their joint payoff is independent of the degree of integration elsewhere. Thus, the return to integration does not depend on prior integration.

When there is an impact on total profits from integration, note that FI is more likely to generate a bandwagon effect than BI. However, it is possible that integration could reduce industry profits. In this case, an initial merger may reduce the incentives for a second merger.

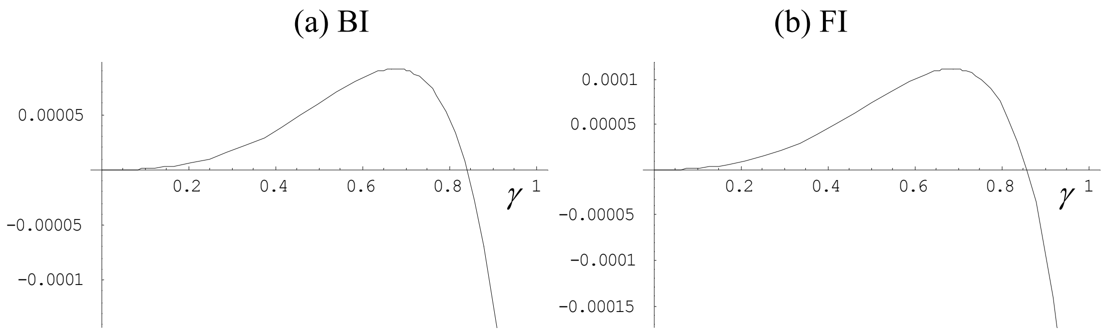
EXAMPLE (Continued): *In our running example, Figure 6(a) and (b) illustrates the size of the bandwagon effect both BI and FI respectively. The graphs assume that downstream*

[35] The payoffs in Table 3 are calculated using the same procedure as in Table 2 (as documented in the proof of Proposition 4). The remainder of the proposition comes from a direct comparison of the increase in payoff to U_B and D_2 if they merged second compared with the same increase if they merged first. These calculations do presume that a first merger would not be followed by a second one. If a second merger was expected (that is a merger by U_A and D_1 would occur regardless), then they would be indifferent between being the first or second to merge.

[36] BI of U_B and D_2 also rules out the coalition $(\overline{D_2U_A})$, something that is ruled out by FI of U_A and D_1; but this term does not enter the *joint* payoff of U_B and D_2, and therefore it does not affect the *joint* profitability of integration. (Similarly BI of either party rules out $(\overline{D_1U_B})$).

firms care about the source of inputs ($\theta = 1$). In both cases, the bandwagon effect is negative as product differentiation is reduced so that a first merger reduces incentives for a second parallel one. Note that when downstream firms are indifferent as to the source of input supply, by Proposition 2, the bandwagon effect is zero for BI, but for FI it is positive.

Figure 6: Bandwagon Effect
Payoff Increase for D_2-U_B as Second Merger as Opposed to First Merger



In both the upstream competition and monopoly cases, the primary driving force for a bandwagon merger is whether that merger could achieve a greater increment to industry profit than the initial merger. Given the usual concavity assumptions on firm profits, a further reduction in quantity produced in the industry following a second merger will not generate this additional incentive. Hence, there will often be a greater payoff to the initial merging parties than subsequent ones.

6 Conclusions

This paper has sorted out alternative claims regarding the impact of upstream competition on the incentives and consequences for vertical integration. While vertical integration that occurs when there is an upstream monopoly has the greatest potential to cause higher prices and lower consumer welfare, this need not translate into greater incentives for purely strategic vertical integration. Specifically, those incentives may be higher when there is upstream competition (especially if downstream competition is not too intense) and may be higher for backward integration (from the competitive into the monopolistic segment) than for forward integration (akin to the more conventional picture of an acquiring monopolistic firm).

In terms of competition and anti-trust analysis, our results support the notion that proposed vertical mergers involving a monopoly bottleneck are of greater concern than where there is upstream competition. Nonetheless, in terms of policies designed to restructure industries and encourage upstream competition (such as those that have occurred in cable television and telecommunications), the potential gains associated with these moves may be mitigated as it could encourage greater strategic vertical integration.

Nonetheless, while our model has synthesized and generalized existing models in the strategic vertical integration literature – as well as providing a framework linking these to models in the property rights literature – there are many possible extensions. In particular, moving beyond the simple 2 by 2 case would be useful. This could be by expanding the number of upstream and downstream assets as well as deepening the vertical chain of production. This would allow a mapping between our work and the work of Hendricks and McAfee (2000) who provide a means of linking concentration measures and integration in vertical segments with the potential for anticompetitive harm from a merger. Their work is based on a mechanism design approach to vertical relations whereas ours uses a non-cooperative bargaining model. This would also provide a means of dealing more carefully with the impact of vertical integration on entry.

Appendix A: Proofs of Propositions

Proof of Propositions 1, 2 and 4:

Take a given sequence of negotiations. The first negotiating pair, bargaining in an alternating offer format, offer a price and a quantity to each other with an exogenous risk of breakdown following any non-accepted offer. This is the format of Binmore, Rubinstein and Wolinsky (1986) and they demonstrate that the unique subgame perfect equilibrium of this bargaining game is the Nash bargaining solution. For example, between D_i and U_j, the bargaining solution will be the solution to the following problem:

$$\max_{q_{ij},p_{ij}} \left(\pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB}) - p_{iA} - p_{iB} - \Phi_{ij}\right)\left(p_{1j} + p_{2j} - c_j(q_{1j},q_{2j}) - \Phi_{ji}\right)$$

Under passive beliefs, the outcomes of any agreement in this bargaining game will not impact on the negotiating parties expectations of agreements that will be reached in any subsequent negotiation (that is, p_{ij} and q_{ij} are taken as given for any negotiation not involves both D_i and U_j). Hence, price in each negotiating pair will be determined by equations (2) to (5). The first order condition for quantity will be:

$$\tfrac{\partial c_j(q_{1j},q_{2j})}{\partial q_{ij}}\left(\pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB}) - p_{iA} - p_{iB} - \Phi_{ij}\right) = \tfrac{\partial \pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB})}{\partial q_{ij}}\left(p_{1j} + p_{2j} - c_j(q_{1j},q_{2j}) - \Phi_{ji}\right)$$

$$\Rightarrow \tfrac{\partial c_j(q_{1j},q_{2j})}{\partial q_{ij}} = \tfrac{\partial \pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB})}{\partial q_{ij}} \text{ (substituting equations (2) to (5) below)}$$

Thus, quantity will be chosen to maximize the joint profits of each negotiating pair. That is, $q_{ij}^* \in \arg\max_{q_{ij}} \pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB}) - c_j(q_{1j},q_{2j})$. If there are no competitive externalities and quantities can be renegotiated in any breakdown subgame, under passive beliefs, these are the only terms in industry profits containing q_{ij}; hence, if all negotiating pairs choose their respective quantities to maximize joint profits, by our concavity assumptions, industry profits will be maximized. This establishes efficiency for the no externality case (Proposition 1).

When there are competitive externalities, each pair chooses a quantity that maximizes joint profits taking the quantities chosen in other pairs as given. However, these quantities are chosen in a manner that equates marginal downstream profit to marginal upstream cost. Note that if instead downstream firms chose their quantities based on a per unit upstream price, say ρ_{ij}, they would choose their quantities to satisfy $\frac{\partial \pi_i}{\partial q_{ij}} = \rho_{ij}$. If $\rho_{ij} = \frac{\partial c_j}{\partial q_{ij}}$, then this will yield the same outcome as in each negotiation (establishing Proposition 2).

For distribution, given passive beliefs, in the initial subgame, there are four bargaining pairs, the pricing outcomes of which are described by the following equations.

$$\pi_1(q_{1A},q_{1B},q_{2A},q_{2B}) - \tilde{p}_{1A} - \tilde{p}_{1B} - \Phi_{1A} = \tilde{p}_{1A} + \tilde{p}_{2A} - c_A(q_{1A},q_{2A}) - \Phi_{A1} \quad (2)$$

$$\pi_1(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{p}_{1A}-\tilde{p}_{1B}-\Phi_{1B}=\tilde{p}_{1B}+\tilde{p}_{2B}-c_B(q_{1B},q_{2B})-\Phi_{B1} \quad (3)$$
$$\pi_2(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{p}_{2A}-\tilde{p}_{2B}-\Phi_{2A}=\tilde{p}_{1A}+\tilde{p}_{2A}-c_A(q_{1A},q_{2A})-\Phi_{A2} \quad (4)$$
$$\pi_2(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{p}_{2A}-\tilde{p}_{2B}-\Phi_{2B}=\tilde{p}_{1B}+\tilde{p}_{2B}-c_B(q_{1B},q_{2B})-\Phi_{B2} \quad (5)$$

where Φ_{ij} and Φ_{ji} represent the payoffs D_i and U_j expect to receive in the renegotiation subgame triggered by a breakdown in their negotiations. Solving these equations recursively, including the payoffs of each renegotiation subgame, allows us to derive the equilibrium payoffs of each firm as in Table 2 (Proposition 4).

Under integration, the equations change. For example, for FI, the resulting (Nash) bargaining equations become:

$$\tilde{t}_{1A}-\Phi_{1A}=\pi_1(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{t}_{1A}-\tilde{p}_{1B}+\tilde{p}_{2A}-c_A(q_{1A},q_{2A})-\Phi_{A1} \quad (6)$$
$$\pi_1(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{t}_{1A}-\tilde{p}_{1B}+\tilde{p}_{2A}-c_A(q_{1A},q_{2A})-\Phi_{AB}=\tilde{p}_{1B}+\tilde{p}_{2B}-c_B(q_{1B},q_{2B})-\Phi_{BA} \quad (7)$$
$$\pi_2(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{p}_{2A}-\tilde{p}_{2B}-\Phi_{2A}=\pi_1(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{t}_{1A}-\tilde{p}_{1B}+\tilde{p}_{2A}-c_A(q_{1A},q_{2A})-\Phi_{A2} \quad (8)$$
$$\pi_2(q_{1A},q_{1B},q_{2A},q_{2B})-\tilde{p}_{2A}-\tilde{p}_{2B}-\Phi_{2B}=\tilde{p}_{1B}+\tilde{p}_{2B}-c_B(q_{1B},q_{2B})-\Phi_{B2} \quad (9)$$

Notice that there is a change in negotiating pairs relative to the non-integrated case. U_A negotiates a supply agreement with U_B for the supply of inputs to D_1. This is because the residual control rights of the downstream asset have been transferred to U_A. Again, solving these equations recursively, including the payoffs of each renegotiation subgame, allows us to derive the equilibrium payoffs of each firm as in Table 2 (Proposition 4).

Proof of Proposition 3

Suppose that $\pi_i(q_{iA},q_{iB},q_{-iA},q_{-iB})=P(q_{1A}+q_{1B},q_{2A}+q_{2B})(q_{iA}+q_{iB})$. Then, under both upstream monopoly and competition, with non-integration, equilibrium quantities are determined by:

$$q_{1A}:\tfrac{\partial P}{\partial q_{1A}}(q_{1A}+q_{1B})+P(.)\le\tfrac{\partial c_A}{\partial q_{1A}} \quad (10)$$
$$q_{1B}:\tfrac{\partial P}{\partial q_{1B}}(q_{1A}+q_{1B})+P(.)\le\tfrac{\partial c_B}{\partial q_{1B}} \quad (11)$$
$$q_{2A}:\tfrac{\partial P}{\partial q_{2A}}(q_{2A}+q_{2B})+P(.)\le\tfrac{\partial c_A}{\partial q_{2A}} \quad (12)$$
$$q_{2B}:\tfrac{\partial P}{\partial q_{2B}}(q_{2A}+q_{2B})+P(.)\le\tfrac{\partial c_B}{\partial q_{2B}} \quad (13)$$

Suppose that each downstream firm was supplied positive input quantities from each upstream firm and each of the above conditions held with equality. Then, $q_{1A}+q_{1B}$ must equal $q_{2A}+q_{2B}$. Note that if, say, both q_{1A} and q_{1B} are strictly positive, both (10) and (11) hold with equality implying that $\tfrac{\partial c_A}{\partial q_{1A}}=\tfrac{\partial c_A}{\partial q_{2A}}$. This can only be true if isoquants are linear (in which case any combination of q_{1A} and q_{1B} satisfying $q_{1A}+q_{1B}$ is an equilibrium. If isoquants are strictly concave, then $\tfrac{\partial c_A}{\partial q_{1A}}\neq\tfrac{\partial c_A}{\partial q_{2A}}$ implying that either one of (10) and (11) hold with equality with the other being a strict inequality. Applying the same logic to D_2's inputs, an equilibrium outcome exists that involves $q_{2A}=q_{1B}=0$ and $q_{1A}=q_{2B}$ at their Cournot equilibrium quantities with (10) and (13) holding with equality but (11) and (12) have a strict inequality if isoquants are strictly concave (as $\frac{\partial c_A}{\partial q_{1A}} < \frac{\partial c_A}{\partial q_{2A}}$ and $\frac{\partial c_B}{\partial q_{1B}} < \frac{\partial c_B}{\partial q_{2B}}$) and having an equality if isoquants are linear (as $\frac{\partial c_A}{\partial q_{1A}} = \frac{\partial c_A}{\partial q_{2A}}$ and $\frac{\partial c_B}{\partial q_{1B}} = \frac{\partial c_B}{\partial q_{2B}}$).

Under upstream monopoly (ii), with vertical integration, equilibrium quantities are determined by:

$$q_{1A} : \frac{\partial P}{\partial q_{1A}}(q_{1A} + q_{1B}) + P(.) \leq \frac{\partial c_A}{\partial q_{1A}} \tag{14}$$

$$q_{1B} : \frac{\partial P}{\partial q_{1B}}(q_{1A} + q_{1B}) + P(.) \leq \frac{\partial c_B}{\partial q_{1B}} \tag{15}$$

$$q_{2A} : \frac{\partial P}{\partial q_{2A}}(q_{1A} + q_{1B} + q_{2A} + q_{2B}) + P(.) \leq \frac{\partial c_A}{\partial q_{2A}} \tag{16}$$

$$q_{2B} : \frac{\partial P}{\partial q_{2B}}(q_{1A} + q_{1B} + q_{2A} + q_{2B}) + P(.) \leq \frac{\partial c_B}{\partial q_{2B}} \tag{17}$$

If (14) and (15) hold with equality, because $\frac{\partial P}{\partial q_{1j}} < 0$, (16) and (17) are only satisfied if $q_{2A} + q_{2B} = 0$ while (14) and (15) cannot hold if $q_{2A} + q_{2B} > 0$ and (16) and (17) hold. As $q_{2A} + q_{2B} = 0$, given the perfect substitutes assumption, industry profits are maximized under upstream monopoly. Moreover when $q_{1B} + q_{2B} = 0$, the only way (14) and (16) can simultaneously hold is if $q_{2A} = 0$. Hence, $\hat{\hat{\Pi}}(\overline{D_1 D_2 U_A U_B}) = \Pi(\overline{D_1 D_2 U_A U_B})$. The case for $\hat{\hat{\Pi}}(\overline{D_1 D_2 U_A}) = \Pi(\overline{D_1 D_2 U_A})$ follows analogously.

Under upstream competition (i), (17) is still as in (13) In this case, the only way all four inequalities can be satisfied is if $q_{1B} = q_{2A} = 0$; in which case, given the homogeneity of upstream costs, equilibrium downstream outputs are at their Cournot levels and so total industry profits remains the same as under non-integration. Note that the perfect substitutes assumption is not required in this case.

Appendix B: Feasibility Conditions

In this appendix, we provide explicitly, the conditions for our solution in Table 2 to be feasible. However, we do this for the special case where both upstream and both downstream firms are symmetric. While this simplifies notation, it is not an innocuous assumption. Indeed, it is precisely where one firm is far more productive than another that feasibility may breakdown. Thus, our purpose here is to give a feel for the conditions rather than a comprehensive treatment.

For the symmetric case, under non-integration, feasibility requires the following three inequalities be satisfied:

$$\hat{\Pi}(D_1D_2U_j) \geq \tfrac{1}{2}\Pi(D_iU_j)$$

$$\hat{\Pi}_{-1}(D_1D_2U_AU_B) \geq \max\left\{\begin{array}{l}\hat{\Pi}(D_1D_2U_i) - \tfrac{1}{3}\left(\Pi(D_iU_AU_B) + \Pi(D_iU_j)\right), \\ \Pi(D_iU_AU_B) - \tfrac{1}{3}\left(\hat{\Pi}(D_1D_2U_i) + \Pi(D_iU_j)\right), \\ 2\Pi(D_iU_j, D_{-i}U_{-j}) - \tfrac{1}{3}\left(\hat{\Pi}(D_1D_2U_i) + \Pi(D_iU_AU_B) - \Pi(D_iU_j)\right)\end{array}\right\}$$

$$\hat{\Pi}(D_1D_2U_AU_B) + \tfrac{1}{3}\left(\hat{\Pi}(D_1D_2U_i) + \Pi(D_iU_AU_B) - \Pi(D_iU_j)\right) \geq \hat{\Pi}_{-1}(D_1D_2U_AU_B)$$

where $\hat{\Pi}_{-1}$ is equilibrium industry profits where one downstream-upstream pair cannot trade with one another. Natural sufficient conditions for these to be satisfied are that $\hat{\Pi}(D_1D_2U_AU_B) \geq \hat{\Pi}_{-1}(D_1D_2U_AU_B) \geq \max\{\hat{\Pi}(D_1D_2U_j), \Pi(D_iU_AU_B), 2\Pi(D_iU_j, D_{-i}U_{-j})\}$. Notice that these collapse to $\hat{\Pi}(D_1D_2U_j) \geq \tfrac{1}{2}\Pi(D_iU_j)$ if D_1 and D_2 produce final goods that are perfect substitutes and U_A and U_B are perfectly substitutable for one another (say having identical constant cost functions) as $\hat{\Pi}(D_1D_2U_AU_B) = \hat{\Pi}_{-1}(D_1D_2U_AU_B) = \hat{\Pi}(D_1D_2U_i) = 2\Pi(D_iU_j, D_{-i}U_{-j})$, and $\Pi(D_iU_AU_B) = \Pi(D_iU_j)$. With linear demand ($P = 1 - Q$) and constant costs ($c<1$), this condition is equivalent to: $\tfrac{7}{72}(1-c)^2 > 0$. Thus, the feasibility condition is satisfied.

When integration occurs, the feasibility conditions will be contingent upon whether there is forward or backwards integration. In this case, however, we can gather further information from the fact that integration is possible; namely, that the acquired firm still operates and hence, their payoffs must be feasible. So if U_A took over D_1, then an agreement with D_1 will be presumed to be feasible. This means that it must be the case that: $\hat{\hat{\Pi}}(D_1D_2U_AU_B) + \hat{\hat{\Pi}}(D_1D_2U_i) \geq 2\Pi(D_iU_AU_B)$. Under symmetry, in addition to conditions under non-integration, the following conditions are required for feasibility:

$$3\hat{\hat{\Pi}}_{-B2}(D_1D_2U_AU_B) + \hat{\hat{\Pi}}(D_1D_2U_i) - 3\Pi(D_iU_AU_B) + \Pi(D_iU_j) \geq 0$$

$$3\hat{\hat{\Pi}}_{-B1}(D_1D_2U_AU_B) + \Pi(D_iU_j) \geq \max\left\{3\Pi(D_iU_AU_B) - \hat{\hat{\Pi}}(D_1D_2U_i), 3\hat{\hat{\Pi}}(D_1D_2U_i) - \Pi(D_iU_AU_B)\right\}$$

$$\hat{\hat{\Pi}}_{-A2}(D_1D_2U_AU_B) - \hat{\hat{\Pi}}(D_1D_2U_i) + \Pi(D_iU_j) \geq 0$$

$$3\hat{\hat{\Pi}}(D_1D_2U_AU_B) + \Pi(D_1U_AU_B) - \Pi(D_iU_j) \geq \max\left\{\begin{array}{l}3\hat{\hat{\Pi}}_{-B1}(D_1D_2U_AU_B), \\ 3\hat{\hat{\Pi}}_{-A2}(D_1D_2U_AU_B) - \hat{\hat{\Pi}}(D_1D_2U_i), \\ 3\hat{\hat{\Pi}}_{-B2}(D_1D_2U_AU_B) - 2\Pi(D_iU_j)\end{array}\right\}$$

For the case the perfect substitutes upstream and downstream, these reduce to: $\hat{\Pi}(D_1D_2U_i) \geq \tfrac{1}{3}\Pi(D_iU_j)$ (a weaker condition than that for non-integration).

Figure 1: Extensive Form Game

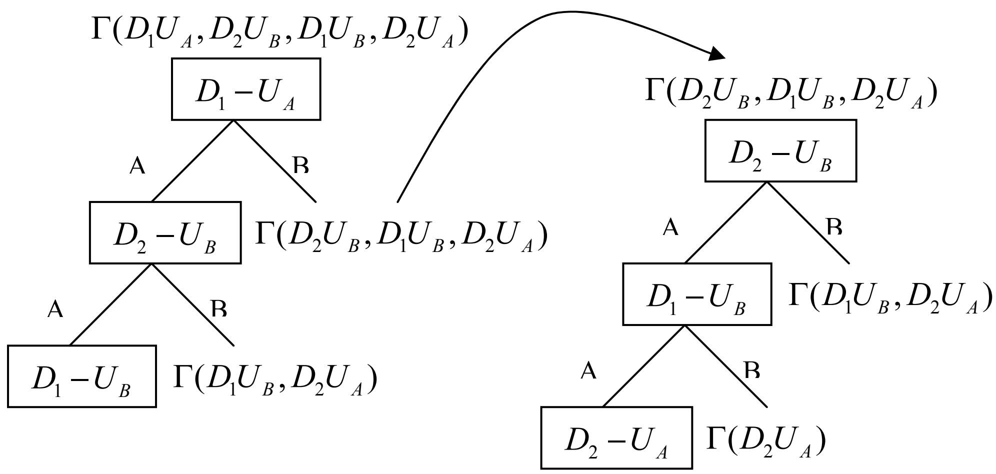
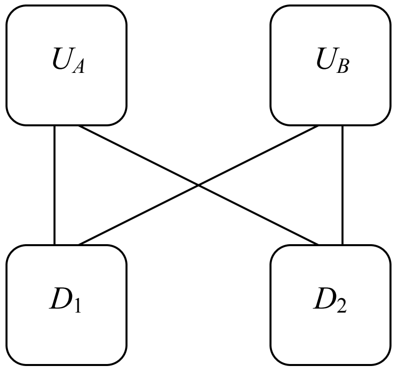
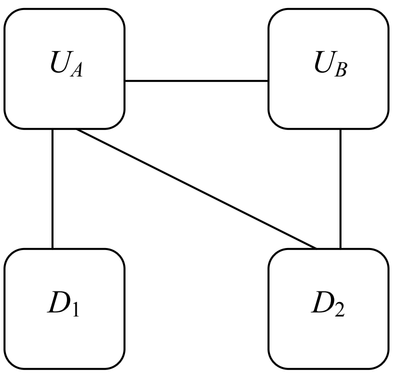


Figure 2: Upstream Competition
Patterns of Negotiation

(a) Non-Integration



(b) Forward Integration



(c) Backwards Integration

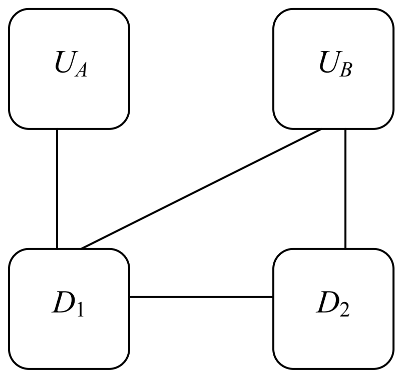


Figure 3: Upstream Monopoly
Patterns of Negotiation

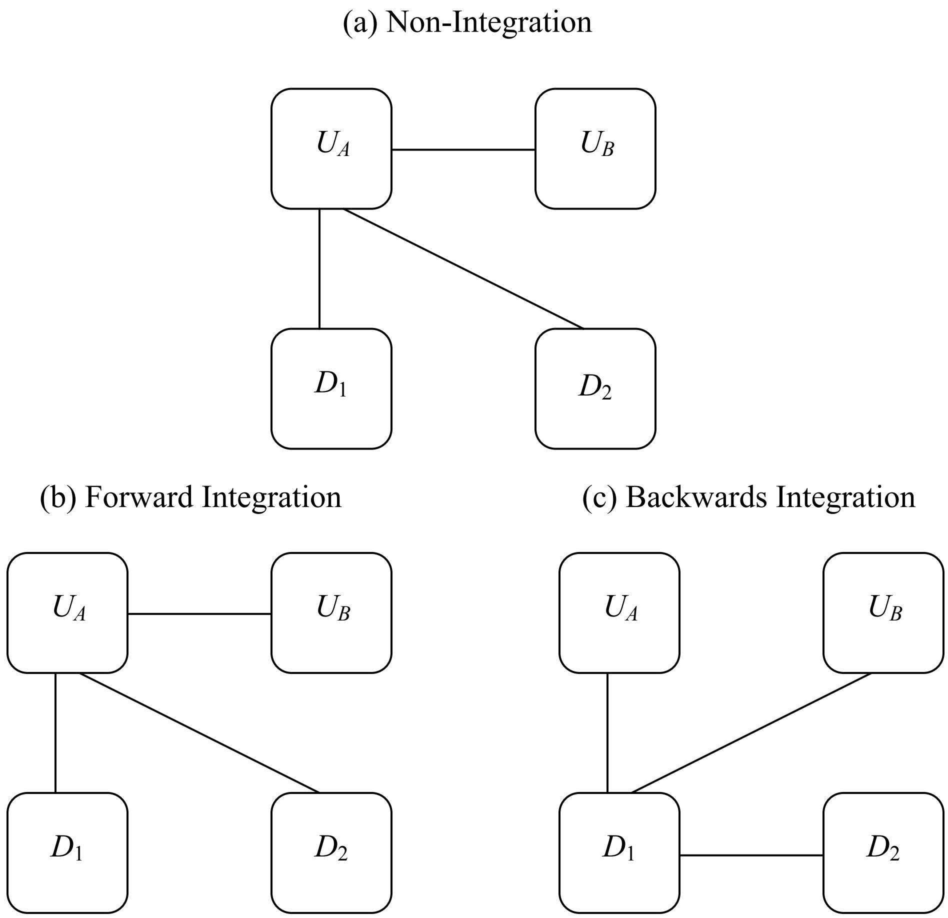


Table 1: Payoffs in No Externality Case
(where (*x*,*y*) = (1,1) for NI, (0,1) for FI and (1,0) for BI)

Upstream Competition	Upstream Monopoly (U_A owns U_B)
$v_{D_1}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A})-3\Pi(\overline{D_2U_B})\\+x\left(\Pi(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})+\Pi(\overline{D_1U_B})\right)\\+y\left(-3\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})\right)-\Pi(\overline{D_2U_A})\right)\end{array}\right)$	$v_{D_1}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A})\\+(1-y)\Pi(\overline{D_1D_2U_B})-3y\Pi(\overline{D_2U_AU_B})\\-y\Pi(\overline{D_2U_A})+(1-y)\Pi(\overline{D_1U_B})\end{array}\right)$
$v_{D_2}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\-3\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A})+3\Pi(\overline{D_2U_B})\\+x\left(\Pi(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})-\Pi(\overline{D_1U_B})\right)\\+y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})+\Pi(\overline{D_2U_A})\right)\end{array}\right)$	$v_{D_2}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\-3\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A})\\+(1-y)\Pi(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B})\\+y\Pi(\overline{D_2U_A})-(1-y)\Pi(\overline{D_1U_B})\end{array}\right)$
$v_{U_A}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A})-3\Pi(\overline{D_2U_B})\\+x\left(-3\left(\Pi(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})\right)-\Pi(\overline{D_1U_B})\right)\\+y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})+\Pi(\overline{D_2U_A})\right)\end{array}\right)$	$v_{U_A}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})+\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A})\\-3(1-y)\Pi(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B})\\+y\Pi(\overline{D_2U_A})-(1-y)\Pi(\overline{D_1U_B})\end{array}\right)$
$v_{U_B}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})-3\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A})+3\Pi(\overline{D_2U_B})\\+x\left(\Pi(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})+\Pi(\overline{D_1U_B})\right)\\+y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})-\Pi(\overline{D_2U_A})\right)\end{array}\right)$	$v_{U_B}=\frac{1}{12}\left(\begin{array}{l}3\Pi(\overline{D_1D_2U_AU_B})-3\Pi(\overline{D_1D_2U_A})\\+\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A})\\+(1-y)\Pi(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B})\\-y\Pi(\overline{D_2U_A})+(1-y)\Pi(\overline{D_1U_B})\end{array}\right)$
$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-x)}=\frac{1}{6}\left(\Pi(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})\right)$	$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-x)}=0$
$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-y)}=\frac{1}{6}\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})\right)$	$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-y)}=\frac{1}{6}\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_1D_2U_B})\right)$

Table 2: Payoffs in Competitive Externality Case
(where (*x*,*y*) = (1,1) for NI, (0,1) for FI and (1,0) for BI)

Upstream Competition	Upstream Monopoly (U_A owns U_B)
$v_{D_1}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right) \\ +(1-xy)\left(3\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})-2\Pi(\overline{D_1U_A})+3\Pi(\overline{D_1U_B})-3\Pi(\overline{D_2U_A}) \\ +3\Pi(\overline{D_1U_A},\overline{D_2U_B})-3\Pi(\overline{D_2U_B},\overline{D_1U_A}) \\ +x\left(\hat{\Pi}(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})-2\Pi(\overline{D_1U_B})+3\Pi(\overline{D_2U_A})\right) \\ +y\left(-3\Pi(\overline{D_2U_AU_B})+3\Pi(\overline{D_2U_B})+2\Pi(\overline{D_2U_A})-3\Pi(\overline{D_1U_B})\right) \\ +xy\left(3\Pi(\overline{D_1U_B},\overline{D_2U_A})-3\Pi(\overline{D_2U_A},\overline{D_1U_B})\right) \end{pmatrix}$	$v_{D_1}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right)+ \\ (1-xy)\left(3\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A}) \\ +(1-y)\hat{\Pi}(\overline{D_1D_2U_B})-3y\Pi(\overline{D_2U_AU_B}) \\ -y\Pi(\overline{D_2U_A})+(1-y)\Pi(\overline{D_1U_B}) \end{pmatrix}$
$v_{D_2}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right) \\ +(1-xy)\left(3\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ -3\Pi(\overline{D_1U_AU_B})+2\Pi(\overline{D_1U_A})-3\Pi(\overline{D_1U_B})+3\Pi(\overline{D_2U_A}) \\ -3\Pi(\overline{D_1U_A},\overline{D_2U_B})+3\Pi(\overline{D_2U_B},\overline{D_1U_A}) \\ +x\left(\hat{\Pi}(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})+2\Pi(\overline{D_1U_B})-3\Pi(\overline{D_2U_A})\right) \\ +y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})-2\Pi(\overline{D_2U_A})+3\Pi(\overline{D_1U_B})\right) \\ +xy\left(-3\Pi(\overline{D_1U_B},\overline{D_2U_A})+3\Pi(\overline{D_2U_A},\overline{D_1U_B})\right) \end{pmatrix}$	$v_{D_2}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right)+ \\ (1-xy)\left(3\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ -3\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A}) \\ +(1-y)\hat{\Pi}(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B}) \\ +y\Pi(\overline{D_2U_A})-(1-y)\Pi(\overline{D_1U_B}) \end{pmatrix}$
$v_{U_A}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right) \\ +(1-xy)\left(3\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})-2\Pi(\overline{D_1U_A})-3\Pi(\overline{D_1U_B})+3\Pi(\overline{D_2U_A}) \\ +3\Pi(\overline{D_1U_A},\overline{D_2U_B})-3\Pi(\overline{D_2U_B},\overline{D_1U_A}) \\ +x\left(-3\hat{\Pi}(\overline{D_1D_2U_B})+3\Pi(\overline{D_2U_B})+2\Pi(\overline{D_1U_B})-3\Pi(\overline{D_2U_A})\right) \\ +y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})-2\Pi(\overline{D_2U_A})+3\Pi(\overline{D_1U_B})\right) \\ +xy\left(-3\Pi(\overline{D_1U_B},\overline{D_2U_A})+3\Pi(\overline{D_2U_A},\overline{D_1U_B})\right) \end{pmatrix}$	$v_{U_A}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})+\hat{\Pi}(\overline{D_1D_2U_A})\right)+ \\ (1-xy)\left(3\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})+\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})+\Pi(\overline{D_1U_A}) \\ -3(1-y)\hat{\Pi}(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B}) \\ +y\Pi(\overline{D_2U_A})-(1-y)\Pi(\overline{D_1U_B}) \end{pmatrix}$
$v_{U_B}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})-3\hat{\Pi}(\overline{D_1D_2U_A})\right) \\ +(1-xy)\left(3\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})-3\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})+2\Pi(\overline{D_1U_A})+3\Pi(\overline{D_1U_B})-3\Pi(\overline{D_2U_A}) \\ -3\Pi(\overline{D_1U_A},\overline{D_2U_B})+3\Pi(\overline{D_2U_B},\overline{D_1U_A}) \\ +x\left(\hat{\Pi}(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})-2\Pi(\overline{D_1U_B})+3\Pi(\overline{D_2U_A})\right) \\ +y\left(\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})+2\Pi(\overline{D_2U_A})-3\Pi(\overline{D_1U_B})\right) \\ +xy\left(3\Pi(\overline{D_1U_B},\overline{D_2U_A})-3\Pi(\overline{D_2U_A},\overline{D_1U_B})\right) \end{pmatrix}$	$v_{U_B}=\tfrac{1}{12}\begin{pmatrix} xy\left(3\hat{\Pi}(\overline{D_1D_2U_AU_B})-3\hat{\Pi}(\overline{D_1D_2U_A})\right)+ \\ (1-xy)\left(3\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})-3\hat{\hat{\Pi}}(\overline{D_1D_2U_A})\right) \\ +\Pi(\overline{D_1U_AU_B})-\Pi(\overline{D_1U_A}) \\ +(1-y)\hat{\Pi}(\overline{D_1D_2U_B})+y\Pi(\overline{D_2U_AU_B}) \\ -y\Pi(\overline{D_2U_A})+(1-y)\Pi(\overline{D_1U_B}) \end{pmatrix}$
$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-x)}=\tfrac{1}{2}\left(\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})-\hat{\Pi}(\overline{D_1D_2U_AU_B})\right)+\tfrac{1}{6}\begin{pmatrix}\hat{\hat{\Pi}}(\overline{D_1D_2U_A})-\hat{\Pi}(\overline{D_1D_2U_A}) \\ +\hat{\Pi}(\overline{D_1D_2U_B})-\Pi(\overline{D_2U_B})\end{pmatrix}$	$\left.\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-x)}\right\vert_{y=1}=\tfrac{1}{2}\left(\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})-\hat{\Pi}(\overline{D_1D_2U_AU_B})\right)+\tfrac{1}{6}\left(\hat{\hat{\Pi}}(\overline{D_1D_2U_A})-\hat{\Pi}(\overline{D_1D_2U_A})\right)$
$\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-y)}=\tfrac{1}{2}\left(\hat{\hat{\Pi}}_{UC}(\overline{D_1D_2U_AU_B})-\hat{\Pi}(\overline{D_1D_2U_AU_B})\right)+\tfrac{1}{6}\begin{pmatrix}\hat{\hat{\Pi}}(\overline{D_1D_2U_A})-\hat{\Pi}(\overline{D_1D_2U_A}) \\ +\Pi(\overline{D_2U_AU_B})-\Pi(\overline{D_2U_B})\end{pmatrix}$	$\left.\frac{\partial(v_{D_1}+v_{U_A})}{\partial(-y)}\right\vert_{x=1}=\tfrac{1}{2}\left(\hat{\hat{\Pi}}_{UM}(\overline{D_1D_2U_AU_B})-\hat{\Pi}(\overline{D_1D_2U_AU_B})\right)+\tfrac{1}{6}\begin{pmatrix}\hat{\hat{\Pi}}(\overline{D_1D_2U_A})-\hat{\Pi}(\overline{D_1D_2U_A}) \\ +\Pi(\overline{D_2U_AU_B})-\hat{\Pi}(\overline{D_1D_2U_B})\end{pmatrix}$

Table 3: Payoffs from Second Merger

BI by D1-UA followed by BI by D2-UB	FI by D1-UA followed by FI by D2-UB
$v_{D_1} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) + \hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_A}) \\ +\Pi(\overline{D_1U_A}) - 2\Pi(\overline{D_1U_A}) \\ +3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) - 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\hat{\hat{\Pi}}_{B2}(\overline{D_1D_2U_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$	$v_{D_1} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) \\ +\Pi(\overline{D_1U_AU_B}) - \Pi(\overline{D_1U_A}) \\ +3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) - 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ -3\Pi(\overline{D_2U_AU_B}) + 3\Pi(\overline{D_2U_B}) \end{pmatrix}$
$v_{D_2} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) + \hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_A}) \\ -3\Pi(\overline{D_1U_A}) + 2\Pi(\overline{D_1U_A}) \\ -3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) + 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\hat{\hat{\Pi}}_{B2}(\overline{D_1D_2U_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$	$v_{D_2} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) \\ -3\Pi(\overline{D_1U_AU_B}) + 3\Pi(\overline{D_1U_A}) \\ -3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) + 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\Pi(\overline{D_2U_AU_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$
$v_{U_A} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) + \hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_A}) \\ +\Pi(\overline{D_1U_A}) - 2\Pi(\overline{D_1U_A}) \\ +3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) - 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ -3\hat{\hat{\Pi}}_{B2}(\overline{D_1D_2U_B}) + 3\Pi(\overline{D_2U_B}) \end{pmatrix}$	$v_{U_A} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) \\ +\Pi(\overline{D_1U_AU_B}) - \Pi(\overline{D_1U_A}) \\ +3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) - 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\Pi(\overline{D_2U_AU_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$
$v_{U_B} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) - 3\hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_A}) \\ +\Pi(\overline{D_1U_A}) + 2\Pi(\overline{D_1U_A}) \\ -3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) + 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\hat{\hat{\Pi}}_{B2}(\overline{D_1D_2U_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$	$v_{U_B} = \frac{1}{12}\begin{pmatrix} 3\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) \\ +\Pi(\overline{D_1U_AU_B}) - \Pi(\overline{D_1U_A}) \\ -3\Pi(\overline{D_1U_A}, \overline{D_2U_B}) + 3\Pi(\overline{D_2U_B}, \overline{D_1U_A}) \\ +\Pi(\overline{D_2U_AU_B}) - \Pi(\overline{D_2U_B}) \end{pmatrix}$
$\Delta(v_{D_2} + v_{U_B}) = \frac{1}{2}\left(\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) - \hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_AU_B})\right) + \frac{1}{6}\left(\hat{\hat{\Pi}}_{B2}(\overline{D_1D_2U_B}) - \hat{\Pi}_{NI}(\overline{D_1D_2U_B})\right)$	$\Delta(v_{D_2} + v_{U_B}) = \frac{1}{2}\left(\hat{\hat{\Pi}}_{CI}(\overline{D_1D_2U_AU_B}) - \hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_AU_B})\right) + \frac{1}{6}\left(\hat{\hat{\Pi}}_{A1}(\overline{D_1D_2U_A}) - \Pi(\overline{D_1U_A})\right)$

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